

DOCTOR OF PHILOSOPHY

FIDELITY OPTIMIZATION IN VIRTUAL ENVIRONMENTS

Michael V. Capps-DoD Civilian

B.S., University of North Carolina at Chapel Hill, 1994

M.S., University of North Carolina at Chapel Hill, 1996

S.M., Massachusetts Institute of Technology, 1999

Doctor of Philosophy in Computer Science-June 2000

Dissertation Supervisor: Michael J. Zyda, Department of Computer Science

Committee Members: Donald P. Brutzman, Undersea Warfare Academic Group

Rudolph P. Darken, Department of Computer Science

Theodore G. Lewis, Department of Computer Science

David Stotts, University of North Carolina Computer Science

In virtual environment systems, the ultimate goal is delivery of the highest-fidelity user experience possible. This dissertation shows that is possible to increase the scalability of distributed virtual environments (DVEs), in a tractable fashion, through a novel application of optimization techniques. Fidelity is maximized by utilizing the given display and network capacity in an optimal fashion, individually tuned for multiple users, in a manner most appropriate to a specific DVE application.

This optimization is accomplished using the *QUICK* framework for managing the display and request of representations for virtual objects. Ratings of representation Quality, object Importance, and representation Cost are included in model descriptions as special annotations. The *QUICK* optimization computes the fidelity contribution of a representation by combining these annotations with specifications of user task and platform capability.

This dissertation contributes the *QUICK* optimization algorithms; a software framework for experimentation; and associated general-purpose formats for codifying Quality, Importance, Cost, task, and platform capability. Experimentation with the *QUICK* framework has shown overwhelming advantages in comparison with standard resource management techniques.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation

KEYWORDS: Distributed Virtual Environment, Linear Programming, Computer Graphics, Resource Management

AGE REPLACEMENT POLICIES IN MULTIPLE TIME SCALES

Scott G. Frickenstein-Captain, United States Air Force

B.S., United States Air Force Academy, 1990

M.S., Florida State University, 1991

Doctor of Philosophy in Operations Research-June 2000

Dissertation Supervisor: Lyn R. Whitaker, Department of Operations Research

Committee Members: Robert R. Read, Department of Operations Research

Gerald G. Brown, Department of Operations Research

Samuel E. Buttrey, Department of Operations Research

Robert A. Koyak, Department of Operations Research

Craig W. Rasmussen, Department of Mathematics

We develop and estimate optimal age replacement policies for devices whose age is measured in multiple time scales. For example, the age of a jet engine can be measured in chronological time, the number of flight hours, and the number of landings. Under a single-scale age replacement policy, a device is replaced at age τ or upon failure, whichever occurs first. We show that a natural generalization to $k \geq 2$ scales is to replace non-failed devices when their usage path crosses the boundary of a k -dimensional region M , where M is a lower set with respect to the matrix partial order. For lifetimes measured in two scales, we consider two contexts. In the first, devices age along linear usage paths. For this case, we generalize the single-scale long-run average cost and estimate optimal two-scale policies. We show these policies are strongly consistent estimators of the true optimal policies under mild conditions, and study small-sample behavior using simulation. For the second context, in which device usage paths are unknown, we use two-dimensional renewal theory to derive the long-run average cost of a policy. We give examples in both settings and note that these ideas generalize to more than two scales.

DoD KEY TECHNOLOGY AREA: Other (Reliability)

KEYWORDS: Age Replacement, Multiple Time Scales, Renewal Theory

A BOUNDARY-LAYER MODEL OF THERMOCAPILLARY FLOW IN A COLD CORNER

Michael R. Huber-Major, United States Army

B.S., Loyola College, 1982

M.S.E., Johns Hopkins University, 1984

M.S., Naval Postgraduate School, 1993

Doctor of Philosophy in Mathematics-June 2000

Dissertation Supervisor: David Canright, Department of Mathematics

A pool of liquid with a horizontal free surface is bounded on one side by a vertical solid wall, which is maintained at a cold temperature relative to the core flow region. Strong temperature gradients along the surface give rise to surface tension variations (thermocapillary stress), which drives flow. Thin viscous boundary layers form along the surface and wall. A boundary-layer model is designed which captures the dynamics of the cold corner, applicable for any Marangoni number M and Prandtl number P in the convective inertial regime.

Analytical expressions for the velocity and boundary-layer thicknesses are developed, which allow accurate prediction of the flow field. The core flow region (outside the viscous boundary layers) is treated as irrotational flow and Laplace's equation is solved using both a Green's function approach and a complex variables approach in the quarter-plane. The flow along the wall is treated as a plane wall jet.

The two-dimensional unsteady heat equation is solved using an alternating direction implicit method. Results show that the flow into the corner is strong enough to contain the thermal field, compressing the isotherms along the wall after steady-state is reached. Additionally, a uniform stream function prediction is developed, by matching the inner and outer flows, giving a relatively accurate depiction of the flow.

DoD KEY TECHNOLOGY AREAS: Materials, Processes, and Structures, Other (Applied Mathematics)

KEYWORDS: Thermocapillary Flow, Marangoni Number, Prandtl Number, Boundary Layer